ALPHA: Accelerating Low-Cost Plasma Heating and Assembly

ALPHA Annual Review Meeting

Dr. Patrick McGrath, Associate Director for Technology, ARPA-E

August 9th, 2016
Seattle, WA

ALPHA seeks more options for fusion energy

Fusion energy would be transformational:

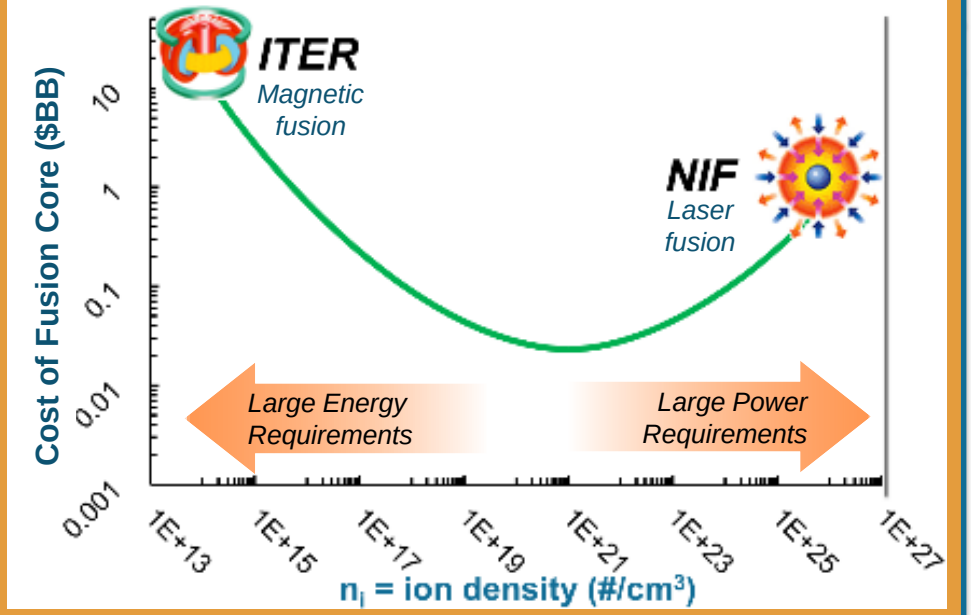
- Carbon-free, dispatchable power
- Virtually unlimited fuel
- No proliferation or meltdown risk

In the ALPHA program, we want to create more options for fusion energy.

…but they have to offer low-cost development pathways to be real options.

ALPHA seeks:

- New approaches to fusion based on low-cost technologies
- High shot rate for rapid learning
- All built to exploit physics of intermediate density regime



Scaling laws for plasma transport point to low-cost options at intermediate ion densities.

Early data (e.g., Sandia's "MagLIF") show great promise.

Success in the ALPHA program will create new options for fusion power that are compatible with private development.

ALPHA portfolio of intermediate density approaches

Los Alamos NATIONAL LABORATORY

Plasma liner implosion by merging supersonic plasma jets

Helion Energy

Staged magnetic compression of field-reversed configuration plasmas.

UNIVERSITY of WASHINGTON

Shear-flow stabilized Z-pinch pushed to higher density and fusion conditions

BERKELEY LAB
Lawrence Berkeley National Laboratory

Scalable ion beam driver based on microelectromechanical systems (MEMS) technology

NumerEx

Piston-driven implosion of rotating liquid metal liner as fusion driver

SWARTHMORE

"Plasma rope" plumes as a potential magneto-inertial fusion target.

Sandia National Laboratories

Compression and heating of high energy density, magnetized plasmas at fusion relevant conditions

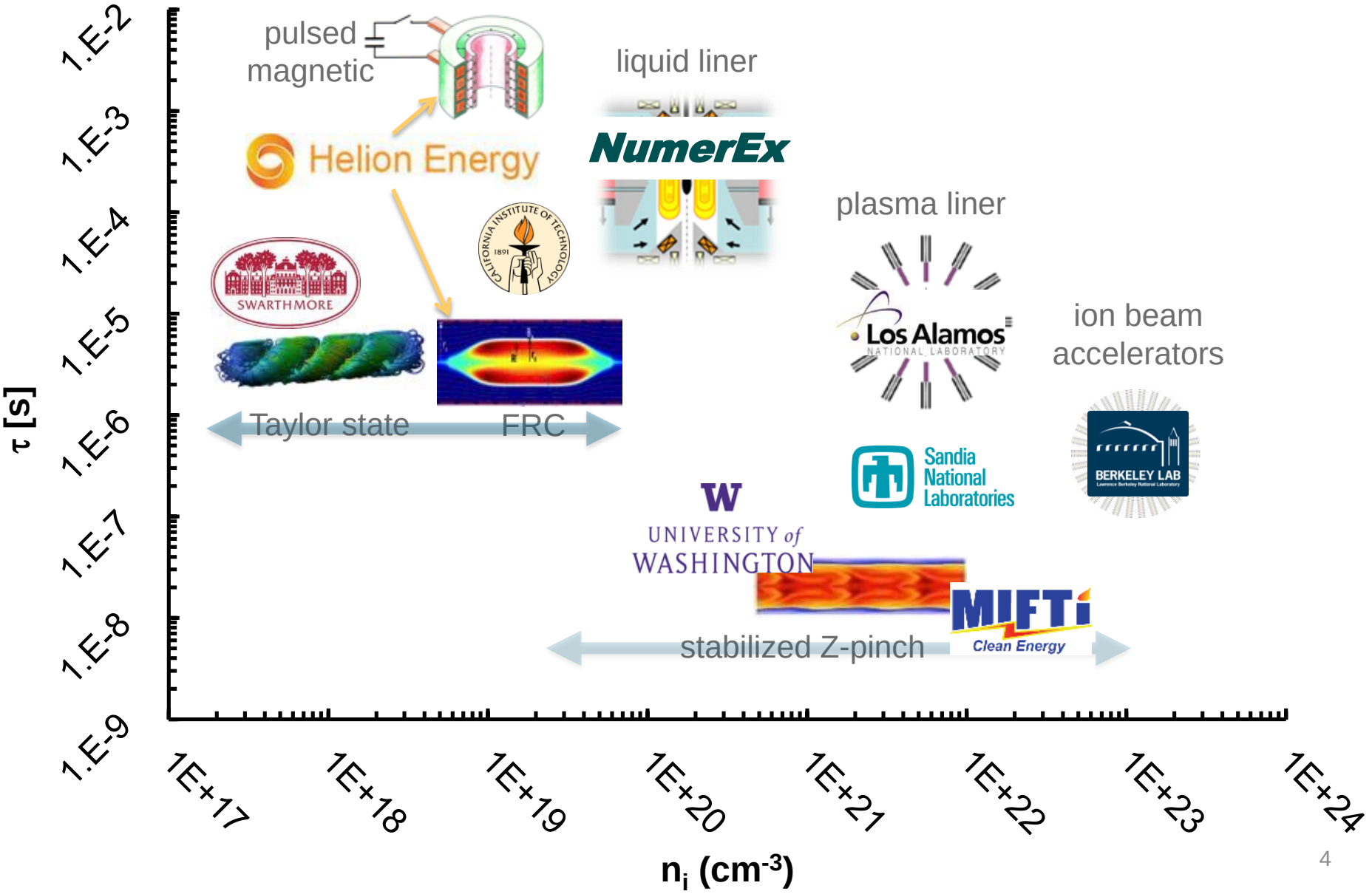
MIFTi
Clean Energy

Staged Z-pinch – a radially-imploding liner on a target plasma

CALIFORNIA INSTITUTE OF TECHNOLOGY 1891

Investigate collisions of plasma jets and targets to characterize fusion scaling laws

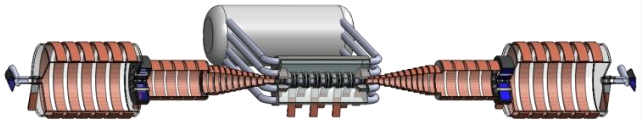
Breadth of ALPHA portfolio



Integrated systems

Helion Energy

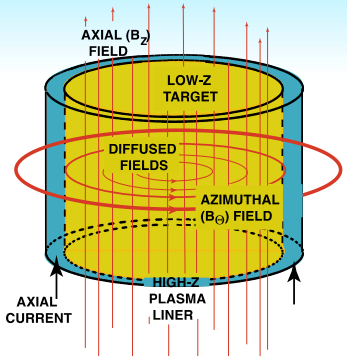
MSNW



Formation, acceleration, merging, and compression of field-reversed configuration (FRC) plasmas to fusion conditions. Staged magnetic compression and magnetic energy recovery offer rapid repetition rates.

MIFTI Clean Energy

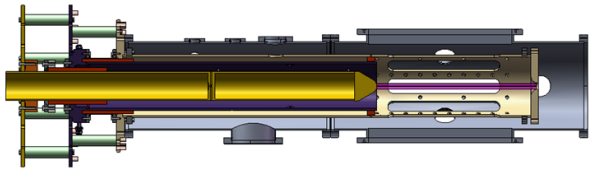
UCSD



Staged z-pinch (radially-imploding liner on a target plasma) offers stable, shock-driven implosion on inner surface (even with unstable outer surface). Magnetic-flux compression confines fusion-reaction products for efficient heating

UNIVERSITY of WASHINGTON

Lawrence Livermore National Laboratory



Shear-flow stabilized z-pinch pushed to high density and temperature. Simple geometry and operation—no field coils—for economical fusion with low-cost and high shot rate.

Success in ALPHA:

Demonstrate stability, scaling, and (ultimately) yield for reactor concept

Drivers

Los Alamos NATIONAL LABORATORY

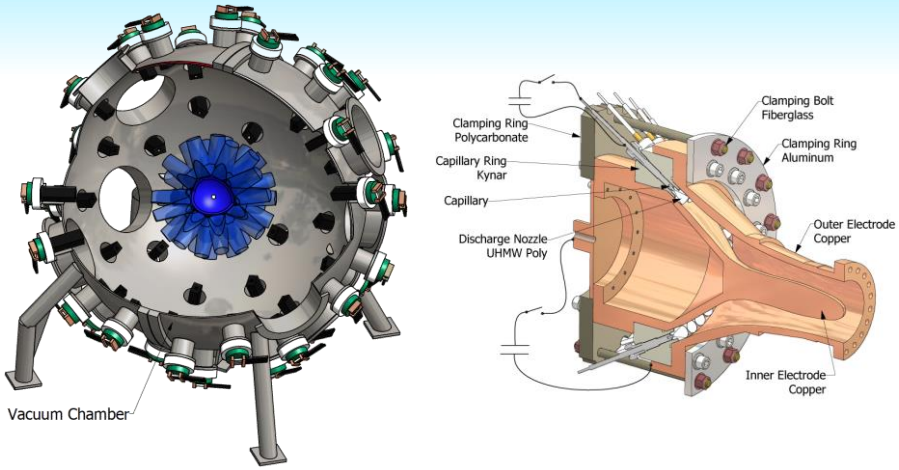
HYPERV TECHNOLOGIES CORP

THE UNIVERSITY of NEW MEXICO

TECH-X

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

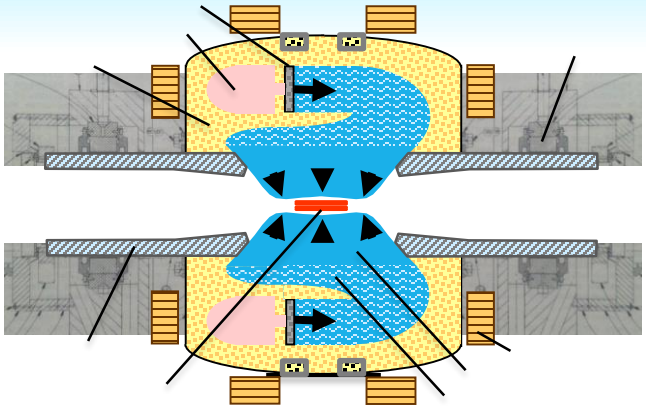
BROOKHAVEN NATIONAL LABORATORY



Merged plasma jets form plasma liners for high velocity implosion of an MIF target. Standoff drivers capable of high repetition rates and high efficiency.

NumerEx

Creative Engineers, Inc.
UNITED STATES | CANADA | INTERNATIONAL



Piston-driven implosion of rotation-stabilized liquid metal liner to compress plasma. High shot rate for development system and multipurpose liner/blanket/thermal medium for power reactor.

Success in ALPHA:

Demonstrate performance (v_{imp}, ram pressure, uniformity) and scaling for MIF reactor

Exploratory Concepts

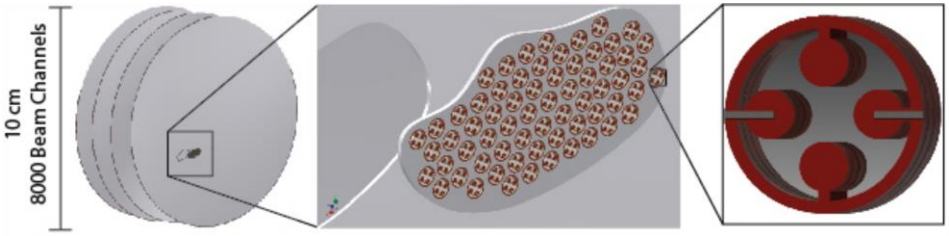
BERKELEY LAB

Cornell University

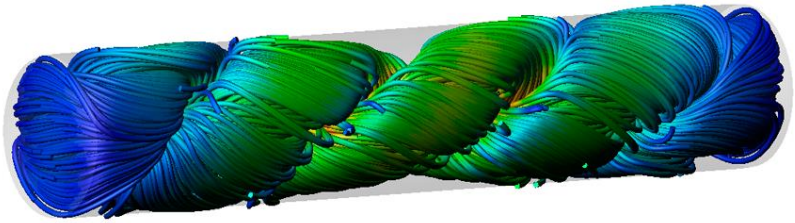
SWARTHMORE

BRYN MAWR COLLEGE

WOODRUFF • SCIENTIFIC



Ion beam driver based on a microelectromechanical systems (MEMS) multi-beamlet accelerator. Demonstrate high current density (10-100x SOA), high efficiency (20-50%) operation of scalable, low-cost technology.



Acceleration, stagnation, and merging of "plasma ropes" (Taylor states) to high density; determine stability limits and lifetime. Assess as long-lived plasma targets for MIF.

Success in ALPHA:

Proof-of-concept for new approaches to fusion drivers (LBNL) and targets (Swarthmore)

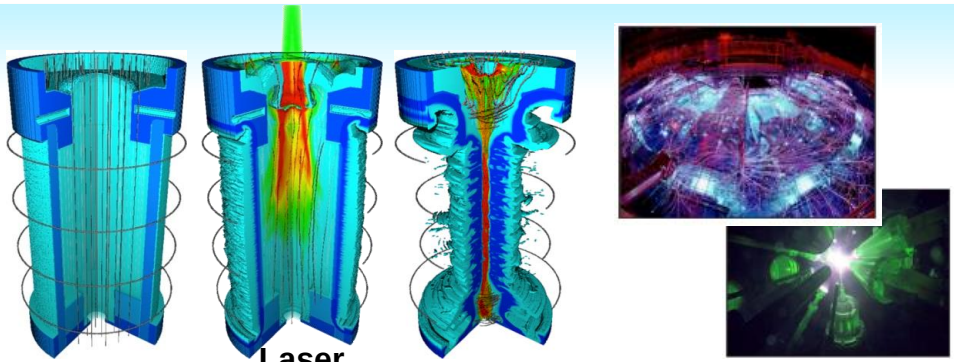
Underlying science of magneto-inertial fusion

Sandia National Laboratories

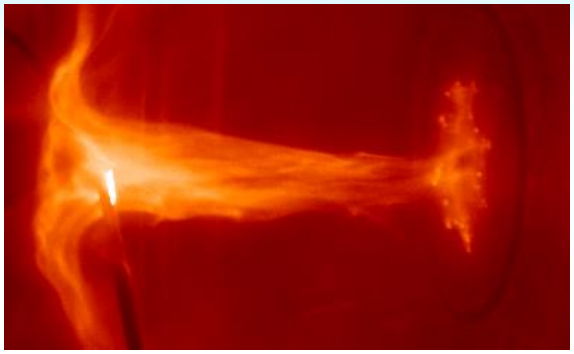
UR LLE

California Institute of Technology 1891

Los Alamos National Laboratory



Compression and heating of high energy density, magnetized plasmas at fusion relevant conditions. "Mini-MagLIF" at LLE enables high experimental throughput.



Collisions of plasma jets with targets in "reversed frame of reference" MIF analogue. Characterize dimensionality of adiabatic compression in MIF.

Success in ALPHA:

Rapid experimentation, benchmarking of codes for MIF concepts

Approaching end of Year 1

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ALPHA kicked off in October 2015

All teams have major go/no-go points at 12-18 months (Fall 2016-Spring 2017)

Fast forward – October 2018

Goals for the meeting

1) **How are we doing?**
   - Technical updates from Year 1 of ALPHA

2) **How can we help each other?**
   - Leveraging expertise, experience, and capabilities across community

3) **How should we structure ourselves for the future?**
   - Charting the fastest way to get fusion out of gov't and into industry

Meeting agenda

Tuesday, 8/9, Day 1: 1 PM-5:30 PM

- Brief round-the-room introductions of teams and attendees
- Government resources for fusion research (Nevada National Security Site, PPPL)
- Panel discussion: private fusion companies (General Fusion, Lockheed, CT-Fusion)
- ALPHA technical updates (UW, Helion, MIFTI)

Wednesday 8/10, Day 2: 9 AM-5 PM

- ALPHA technical updates
  (NumerEx, LANL/Hyper V, Sandia, Caltech, Swarthmore, LBNL/Cornell)
- “Caffeinated problem solving session”
- “Non-traditional” models for private investment and public-private partnership
  (XPRIZE, Chris Daniel)
- Update on the ARPA-E-sponsored cost modeling study
- Breakout sessions on alternative models for fusion R&D.
  (If ALPHA succeeds, what should come next?)

Meet the ARPA-E Team

Ellen Williams
Director of the Advanced Research Projects Agency–Energy (ARPA-E)

Eric Rohlfing
Deputy Director for Technology

David Henshall
Deputy Director for Commercialization

Patrick McGrath
Associate Director for Technology

Ryan Umstattd
Senior Commercialization Advisor

Carlton Reeves
Technology to Market Advisor

Nate Gorence
Technology to Market Advisor

David Brown
ARPA-E Fellow

Scott Vitter
Technology to Market Summer Scholar (UT Austin)

Colleen Nehl
Tech SETA for ALPHA, Booz Allen Hamilton

www.arpa-e.energy.gov